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## LAKE SUPERIOR HIGHLANDS: THEIR ORIGIN AND AGE

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The dominant relief feature of the highland region about Lake Superior is an even, distinctly elevated plain in which the rivers are deeply intrenched. The genesis of this broad upland plain is a moot question of long standing. Its settlement involves the derivation and facial expression of the landscape over more than one-quarter of the entire North American continent.

At first glance the possibilities of the present peneplain's dating back in its formation to Early Cambrian, or even to pre-Cambrian, times, as is sometimes argued, seems so remote as almost to preclude serious consideration. Only by merest chance could there be survival of any remnant of so ancient a grade-plane. This chance lies in the exhuming of the old peneplain by the slow and uniform removal of a soft Paleozoic covering. Such a facet, if it persisted, would be quite small necessarily, coincidental, and, more properly, a product of some subsequent epoch of planation. Proofs of its antiquity have to be sustained by testimony overwhelmingly pertinent and convincing.

Indubitable evidence fixing the age of such a peneplain would not be likely to be found within the area of the highlands itself. It even might not be displayed anywhere within the limits of the great crystalline shield of Canada at all. Probabilities are for its disclosure far outside of the immediate elevated region. It is not a satisfactory solution of the problem to connect such an elevated and dissected plain with one of closely similar attitude emerging from beneath Cambrian sediments. In a continental geologic column there are many old plains—some only of provincial extent, but many of continental span or of dimensions as wide as such plains ever attain. To some place beyond the margins of the highland flats must attention first be turned for testimony bearing upon their age.

In casting about for a favorable locality in which to begin inquiry it is but natural to turn to some spot nearest to the highlands that displays a considerable section of the later geologic formations. There appears to be a section of this description off to the southwest of the middle angle of the Canadian shield, on the south side of the great tongue of pre-Cambrian rocks which extends from Lake Superior into northwestern Iowa where the old terranes are known as the Sioux quartzite.

On the general stratigraphic scheme of Iowa,<sup>1</sup> which is the latest and most complete of any now available, the erosion intervals may be readily indicated, together with the taxonomic values of each. Since some of these lines represent peneplanation sufficiently wide

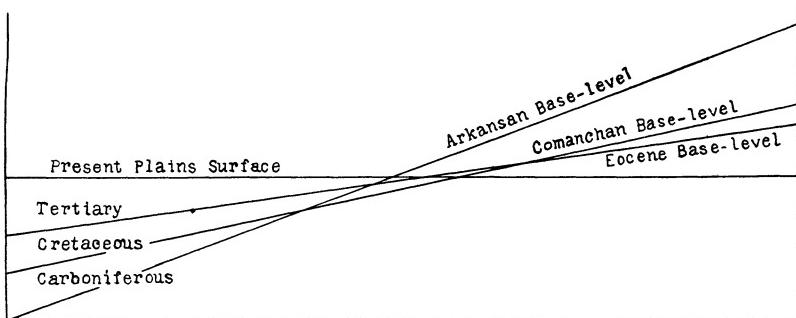


FIG. 1.—Relative attitudes of later base-levelings in Lake Superior region.

in extent to affect the Lake Superior region, they may be critically examined in turn, eliminated, or further compared in order that the parallelism with the highland plain under consideration may be exact.

Of the dozen or more conspicuous planes of unconformity which mark the geologic column of the region the Arkansan, Comanchean, and Eocene horizons are the most important. These represent most assuredly peneplains of great extent. Their intersections with the present ground-surface trend north-northwest through west-central Minnesota and Iowa. Along this line the intersections of all of them chance to be very close together. In diagram they may be represented as in Fig. 1.

<sup>1</sup> *Geol. Surv. Iowa*, XXII (1913), 154.

If the plane in which the lines of the diagram lie be considered as standing in a northeast-southwest direction the several peneplains of the Lake Superior region must have been successively obliterated, leaving only remnants of the very latest ones. The Arkansan peneplain, which constitutes the floor of the Coal Measures in the Upper Mississippi valley north of the Ozarks, may be for the present neglected. For reasons which are to follow, the Comanchean peneplain, which forms the Cretaceous floor in Iowa, Minnesota, and Manitoba, may be particularly examined.

Recent investigations about the point where the three states of Iowa, Minnesota, and South Dakota meet clearly disclose some instructive geologic structures bearing directly upon the problem under consideration. The field data thus acquired are supplemented by numerous deep-well records. By reference to the general geologic map of Iowa the Paleozoic formations are noticed to be distributed in relatively narrow belts trending in a northwest direction across the northeastern one-third of the state. Very singularly, it has always seemed, these belts abruptly terminate at the north soon after the state boundary is passed. This rather peculiar circumstance appears never to have excited curiosity as to its cause. Far to the north, about Winnipeg, in Manitoba, there is the same narrow belting of the same formations and, as farther south, the strike is northwest. The Canadian Paleozoic area is separated in central Minnesota from the Iowan Paleozoic field by a broad expanse of pre-Cambrian rocks.

Structurally these pre-Cambrian rocks form the core of a rather notable arch the axis of which runs northeast and southwest. This anticline is one of large proportions and extends from the east shore of Lake Superior to central South Dakota, where, as a canoe-shaped form, it plunges beneath the post-Paleozoic deposits of the Great Plains. The exposure of Sioux quartzite constitutes the western nose of the fold.

It is against the south slope of the sharp Siouan anticline that the belted Paleozoic terranes of northeastern Iowa are upturned, and there cut off. The eastern margin of the vast Cretaceous field crosses the same line, so that there is apparently no westward extension of the five groups of formations, if it ever existed, at

least on the surface of the ground. On the other, or north, side of the anticline the same belts recur, as already stated.

Bearing in mind the geographic position of this marked anticline, an arch between the center of which and the bases of its limbs there is a stratigraphic interval of more than 5,000 feet, it is quite obvious that the Paleozoic belts originally did not really terminate against it in southern Minnesota but rather extended over it and were continuous with the similar Canadian belts. This being the case, it is equally obvious that the Iowan belts should not only not stop against the arch, but should continue westward along the strike of the fold, but beneath the Cretaceous covering. This is found actually to accord with recently observed facts. A cross-section (Fig. 2), which is drawn to scale, indicates the actual amount of tilting displayed at the present time, with the part originally laid down, but removed during Mid-Cretaceous times, represented by dotted lines.

There are incontrovertible proofs fixing within very narrow limits the geologic date of the uprising of the great Siouan arch, and also the time of its complete reduction again to an even plain lying but little above the level of the sea. Since all of the Paleozoic formations, from Cambrian to latest Carboniferous, take part in the folding while the Cretaceous strata do not, it is manifest that the main movement occurred in Early Mesozoic times, largely during the Triassic and Jurassic periods. Comanchean time (Early Cretaceous) in the region must have been principally a period of rapid, enormous, and very complete denudation, since by the beginning of Mid Cretaceous time, when marine deposition over this part of the continent took place, the floor upon which the sediments were laid down was as even as any known peneplain. The Cretaceous floor is a true plain worn out on the beveled edges of the Paleozoics and older rocks.

The areal distribution and attitude of the Cretaceous beds along their eastern margin is suggestive. In Minnesota the western half of the state is occupied by deposits of Cretaceous age. Outliers occur far to the eastward—to the Mississippi River and the Mesabi Range. The great thickness of Cretaceous deposits in the eastward-facing escarpment of the Duck and Riding mountains, in

Manitoba, and their gentle dip to the west point to their former great eastward extension probably to Lake Superior and Hudson Bay. There is little reason to doubt, therefore, the assumption that the Cretaceous sediments once covered the Lake Superior

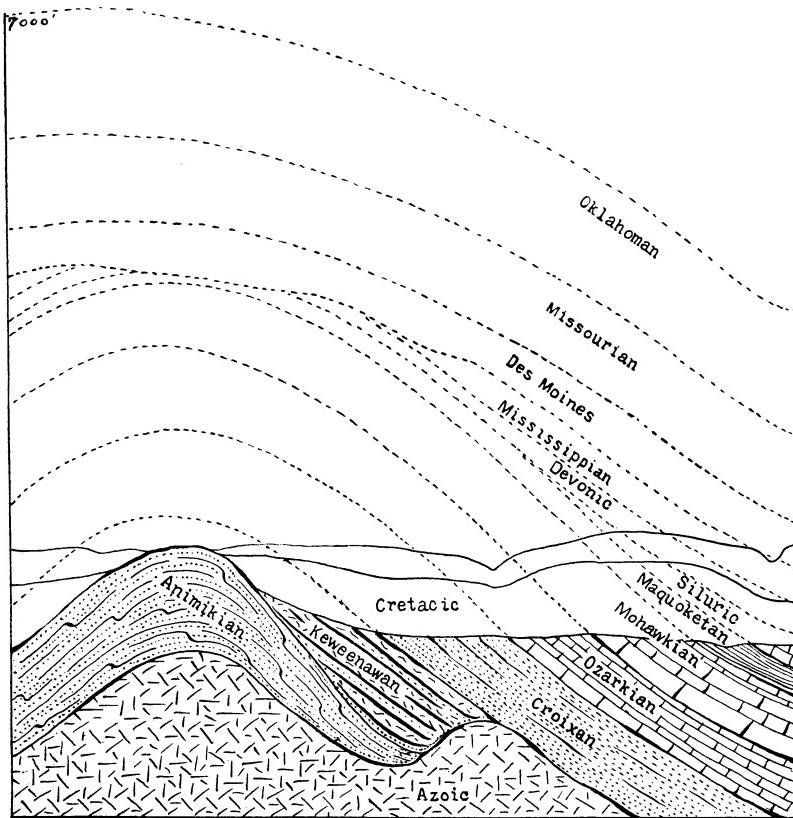


FIG. 2.—Erosion of the Triassic Siouan mountains in southern Minnesota.

highlands and that the peneplain which formed the Cretaceous floor must have imparted the main topographic expression to the highland plain.

In Iowa, and Minnesota also, the Cretaceous strata themselves are notably beveled, but at a lower angle than that of their floor. There are good reasons for believing that this Tertiary base-leveling took place in Eocene time. There appear to be important water-

laid deposits of this age in the region; but Miocene and Pliocene deposits seem to be chiefly, if not entirely, continental in character.

It is quite probable, therefore, that the tops of the monadnocks which rise above the level of the highland plain of Lake Superior represent approximately the level of the Comanchean peneplain; and that the present plain of that region is Eocene in date. This interpretation has many points supporting it; and but few or none against it. Around Lake Superior glacial action has entirely removed the evidence for the ready determination of these supporting facts. The strongest and most convincing testimony comes from neighboring localities; and the several lines of evidence appear to be wholly congruous and mutually supporting.

For the formation of the Lake Superior highlands an Eocene age appears to be conclusive. The necessary consequences are far-reaching. It calls for an examination anew of the geographic development of a large part of the northeastern section of the North American continent.